SPAWNING AREAS AND SEASONS OF THREE CLUPEID SPECIES (*SARDINA PILCHARDUS, SPRATTUS SPRATTUS* AND *ENGRAULIS ENCRASICHOLUS*) IN THE RIA OF VIGO (GALICIAN COASTS, NW SPAIN)

by

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ASTRACT. – Clupeid eggs were sampled monthly throughout a year (September 1979 to October 1980) at 11 stations in the Ria of Vigo (Galician coasts, N.W. Spain). Sampling was carried out with a 20.3 cm diameter Bongo net fitted with a 300 μ and 500 μ mesh net.

Sardine eggs were found in the outer part of the Ria from November to July though the Ria cannot be considered a main spawning area for this species. However, it is a main spawning area for the sprat, with a winter spawning season all over the Ria, but mainly in its central part; and for the anchovy, which enters to spawn in summer in the inner part of the Ria.

RESUME. – Des œufs de Clupeidés ont été collectés mensuellement pendant une année (Septembre 1979-Octobre 1980), selon un quadrillage qui comprend 11 stations dans le Ria de Vigo (côtes de la Galicie, NO de l'Espagne). Les pêches ont été faites avec un filet Bongo de 20,3 cm de diamètre pourvu de deux maillages: 300 μ et 500 μ.

On a trouvé des œufs de sardine dans la partie extérieure de la Ria depuis Novembre jusqu'en Juillet, bien qu'on ne puisse pas penser que ce soit une aire principale de ponte pour cette espèce. Cependant, le Ria peut être défini comme zone principale de ponte pour le sprat, avec une ponte hivernale, et pour l'anchois qui pénètre pour pondre pendant l'été dans la partie la plus continale de la Ria.

Key-words : Spawning, Clupeioidei, ANE Spain, Estuaries, Ichthyoplankton.

INTRODUCTION

The ichthyoplankton of the coasts and Rias of Galicia (NW of Spain) is one of the least known biological aspects of these areas. The only work where an annual ichthyoplankton cycle (in the Ria of Arosa) has been studied is Lopez-Jamar (1977). Other authors, e.g. Lopez Veiga (1977), have presented data for some clupeid species, but they did not complete an annual cycle.

The present work, a partial result of a bioecological study of the Ria of Vigo, studies a complete annual cycle (1979-1980) of the egg phases in three species of Clupeidae : *Sardina pilchardus* (Walbaum), *Sprattus sprattus* (L) and *Engraulis encrasicolus* L., in order to determine the spawning areas and seasons of this species in the Ria.

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Close to Galicia were the studies by Sobral (1975) and Ré (1981, 1982) in Portuguese coasts and estuaries, Villegas (1979) off Asturian coasts and Martin (1982) over the Galician continental platform. The lack of information about the coastal area close to the Ria precludes comparison of what happens inside with what happens outside of it.

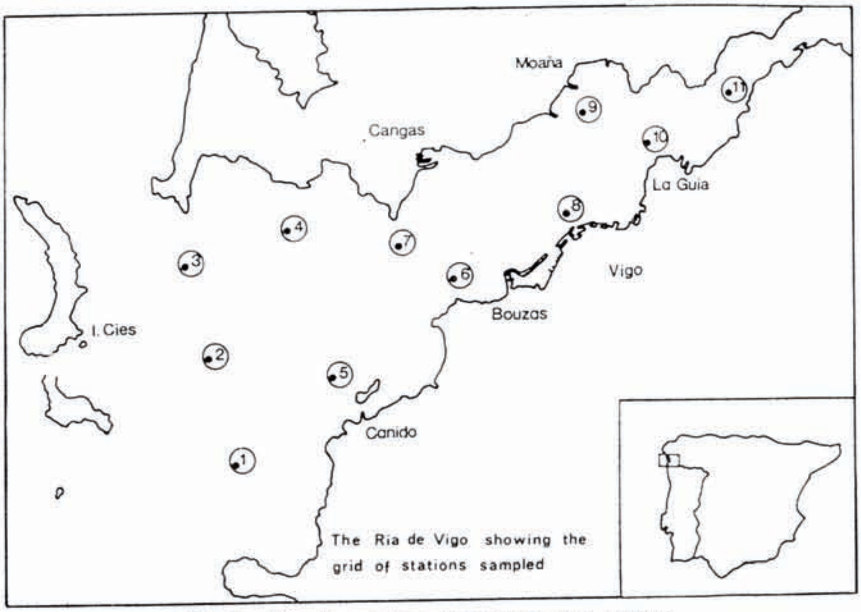


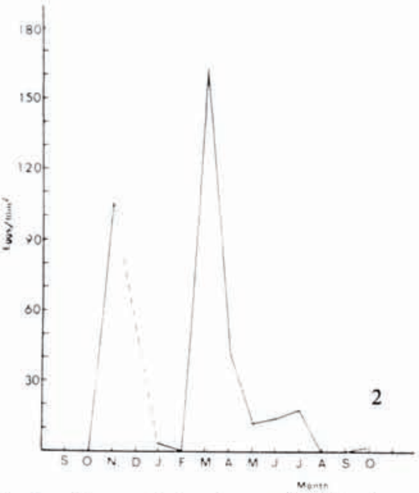
Fig. 1. –Sampling stations (1-11) in the Rìa of Vigo.

MATERIAL AND METHODS

The sampling plan was designed to include the three different areas of the Ria: the inner, middle and outer parts (Alcaraz, 1977) and in each case both northern and southern shores were sampled. Eleven fixed stations (fig. 1) were visited monthly from September 1979 to October 1980, except for December when bad weather prevented the sampling cruise.

The hauls were made on board the ship « Lampadena », during the daylight hours with an ichthyoplankton Bongo net of 20.3 cm mouth diameter provided with two different mesh sizes (300 μ and 500 μ) which did not show significative differences in the retention of eggs of the three fish species. Hauls were double oblique and were made from the bottom to the surface during 4.5 minutes, the speed of the vessel during the haul being 1.5 knots. The average volume of water filtered at each surveyed station, measured with a Flowmeter « General Oceanics » 2030, situated on the mouth of the net, was of 12.5 m^3. The samples were fixed with 4 % formalin buffered with borax.

At each station, the temperature of the water column was measured with a bathythermograph « Termarine Records ». The temperatures used here are the averages for the complete water column. In order, to analyze the salinity, pH,



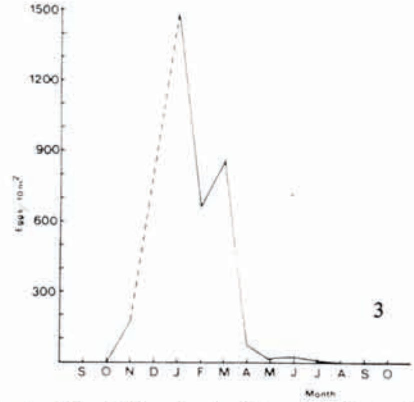


Fig. 2. – Seasonal abundance of pilchard eggs in the Rìa of Vigo during the period September 1979 - October 1980.

Fig. 3. – Seasonal abundance of sprat eggs in the Ría of Vigo during the period September 1979 - October 1980.

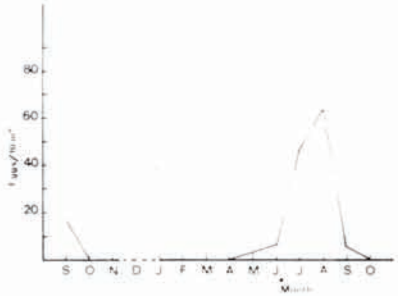


Fig. 4. – Seasonal abundance of anchovy eggs in the Ría of Vigo during the period September 1979 - October 1980.

oxygen, nitrite and nitrate contents of the water, samples were taken using oceanographic bottles at six levels (0, 5, 10, 20, 30 and 40 m depth).

Fish eggs and larvae were separated from the rest of the zooplankton component. For identification and measurements, we used a stereoscopic microscope provided with a micrometer.

The numerical data were adjusted to give the abundance of eggs per 10 m^2 of sea surface and these results are represented for each species by density lines on the maps.

RESULTS AND DISCUSSION

Sardina pilchardus (Walbaum, (1792)

The maps of egg distribution densities in the months of the cycle in which it

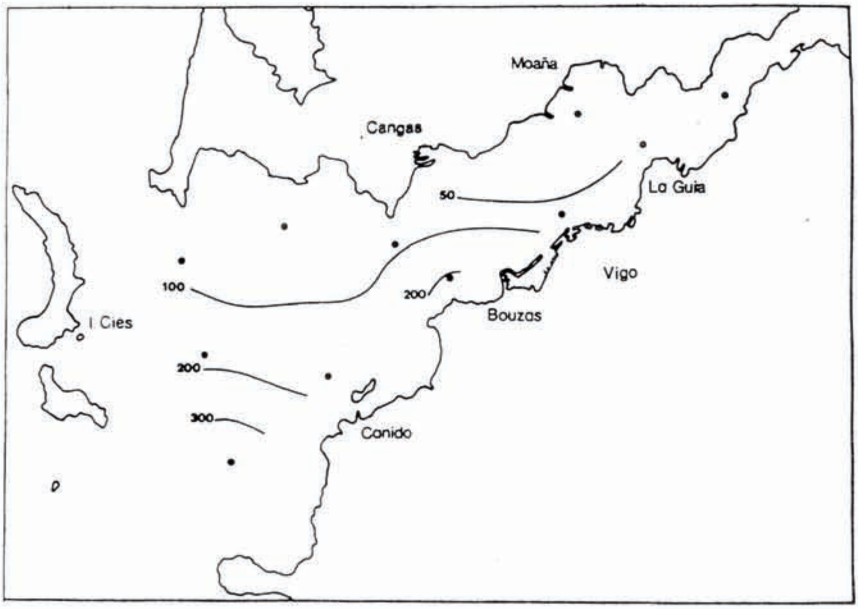


Fig. 5. – Abundance of pilchard eggs and their distribution in the Ría of Vigo in November 1979 (eggs/10m^2 of sea water).

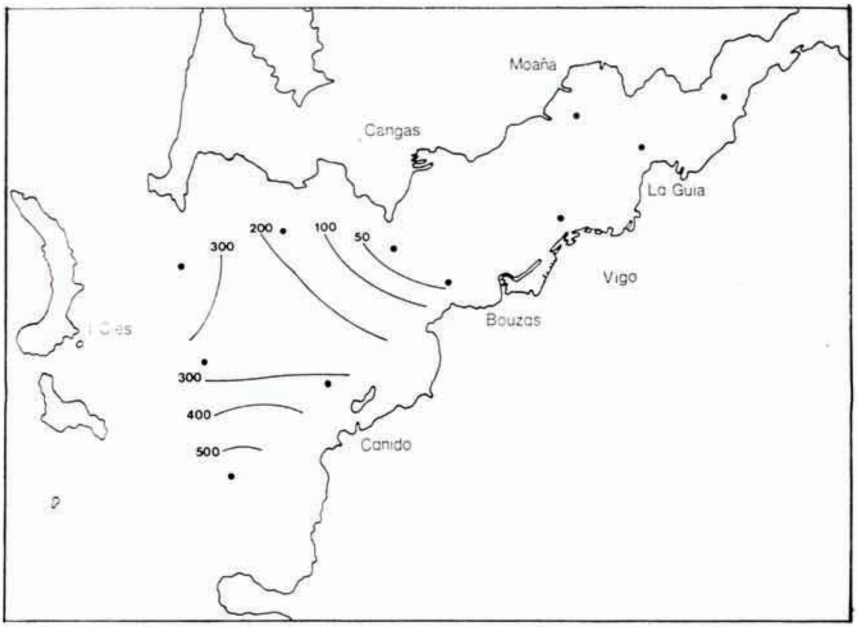


Fig. 6. – Abundance of pilchard eggs and their distribution in the Ría of Vigo in March 1980 (eggs/10m^2 of sea water).

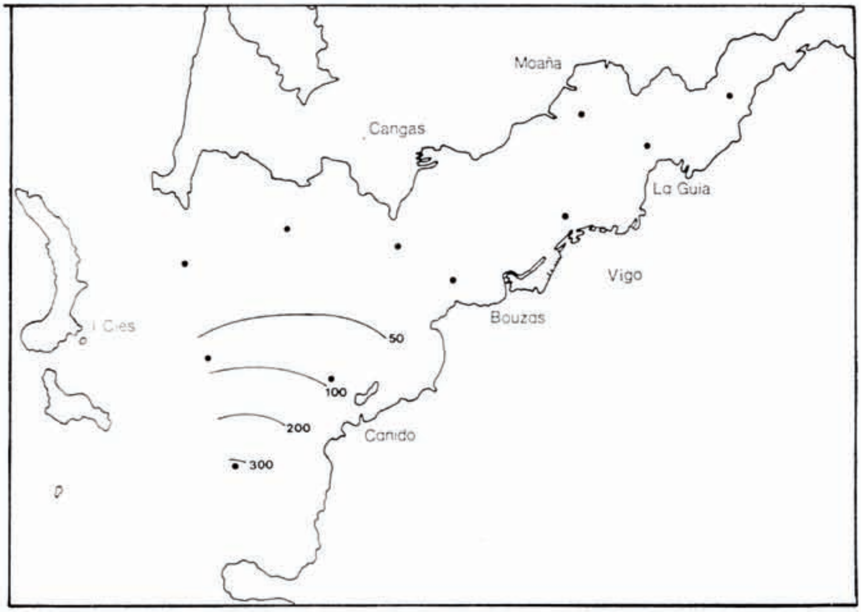


Fig. 7. – Abundance of pilchard eggs and their distribution in the Ría of Vigo in April 1980 (eggs/10m^2 of sea water).

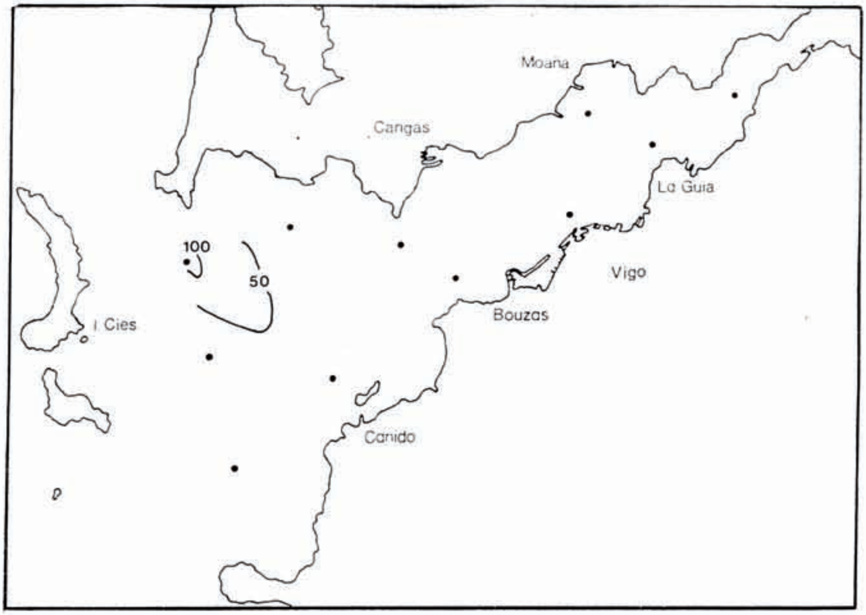


Fig. 8. – Abundance of pilchard eggs and their distribution in the Ría of Vigo in June 1980 (eggs/10m^2 of sea water).

was possible to record them are shown in figures 5 to 8. The greatest densities were found in the outer part of the Ria off its southern shore. Average densities for the entire Ria in the different months are shown in fig. 2.

Are the Galician Rias a spawning area for the sardine, since this point is not clear in earlier literature. Thus, Andreu (1953, 1955) considered spawning in the Rias unusual, while Lopez-Jamar (1977) did not find pilchard eggs in the Ria of Arosa, but blamed predation by the population of *Mytilus sp.* On the other hand, Lopez Veiga (1977) found pilchard eggs in the Ria of Vigo and considered this Ria as a spawning area.

Our data suggest that the Ria of Vigo is not part of the main spawning area of the pilchard, but that a few adults penetrate and spawn in its outer part. According to the circulation system in the Rias proposed by Fraga (1978) it is also quite possible that the eggs are brought in by water currents along the southern shore (where the greatest abundance are found). Thus, one can most likely discard the hypothesis that the Ria of Vigo, and probably the other Rias also, are anything more than the periphery of a main spawning area located off the coast.

It is difficult, therefore, to draw any conclusion about spawning season based on the monthly abundance of eggs in the sampled area (fig. 2). Nevertheless, we postulate two principal spawning seasons, a winter one with a peak in November, and a spring one with a peak in March. Previous studies based on gonad state (De Buen 1927, Navarro 1948, Oliver 1951, 1952, Oliver & Navarro 1952, Andreu 1953, 1955) indicate that spawning takes place over an extended period, from autumn to spring or early summer. However, Lopez Veiga (1977) believed that the principal spawning season was March, April and May while Ré (1981), from ichthyoplankton studies off Portuguese coasts, found two seasonal maxima of spawning similar to our findings, but with the maxima in December and April and a grater intensity in the winter spawning (the reverse of our results, see fig. 2).

In relation to our hydrographical data (temperature and salinity) the greatest numbers of eggs were recorded during the lowest temperatures of the year in the range 13 - 15.1° C. Several authors (Furnestin 1959, Arbault & Boutin 1968, and Arbault & Lacroix 1971) have shown that salinity seems not to be a limiting factor to spawning if the temperature is adequate, i.e. 10-16°C (optimum at 10-12°C). Our own data support this (Table I).

Sprattus sprattus (Linnaeus, 1758).

Sprat eggs were the most abundant of all species taken in the ichthyoplankton cruises, with abundance of 5000 eggs/10 m^2 in January, 3000 eggs/10 m^2 in February and 2500 eggs/10 m^2 in March.

The pattern of monthly densities of eggs (figs. 9 to 15) was fairly constant in the Ria, with an area of maximum abundance in the central-southern part (stations 6 and 8) except during November when the area of maximum abundance was the central-northern zone (stations 4 and 7).

From this distribution and the high egg densities found, it can be infered that the Ria of Vigo is a principal spawning area for the sprat, which confirms for an annual cycle the conclusions of Lopez Veiga (1977) ; it also agrees with the data of Lopez-Jamar (1977) for the Ria of Arosa.

The biology of the sprat is one of best documented among the species of fishes of the coasts of Galicia. The works of Oliver (1950), Arte (1956) and Lopez Veiga (1977) clearly establish its reproductive behaviour based on macroscopic studies of adult gonad state and/or the gonosomatic index. According to these authors, spawning takes place from winter to spring, being more intensive in December, January and February.

The monthly abundance of sprat eggs in the survey area (Fig. 3) shows that the spawning season is long, from October to July, with a maximum in January, February and March. This agrees with the published data, as also with the findings of Lopez-Jamar (1977) in his study of the ichthyoplankton in the Ria of Arosa.

The greatest abundance of sprat eggs occurs with a fall of average temperatures in the water column (Table I). Average temperatures were 13.7° C in November and they remained between 12.75 and 13.15° C until May-June when they increased to 14.5° C and at the same time there was a decrease of the indexes of abundance ; by July, when the average temperature was 14.16° C, there were no more sprat eggs in the plankton.

This range of spawning temperatures is wider than the range shown by most authors, who place it between 8° C and 11° C (Fage 1920, Arbault & Boutin 1968, Arbault & Lacroix, 1971) or between 8° C and 12.5° C (Arbault & Lacroix 1976) although it agree with the data of Lopez Veiga (1977) who recorded 12° to 14° C in the Ria of Vigo.

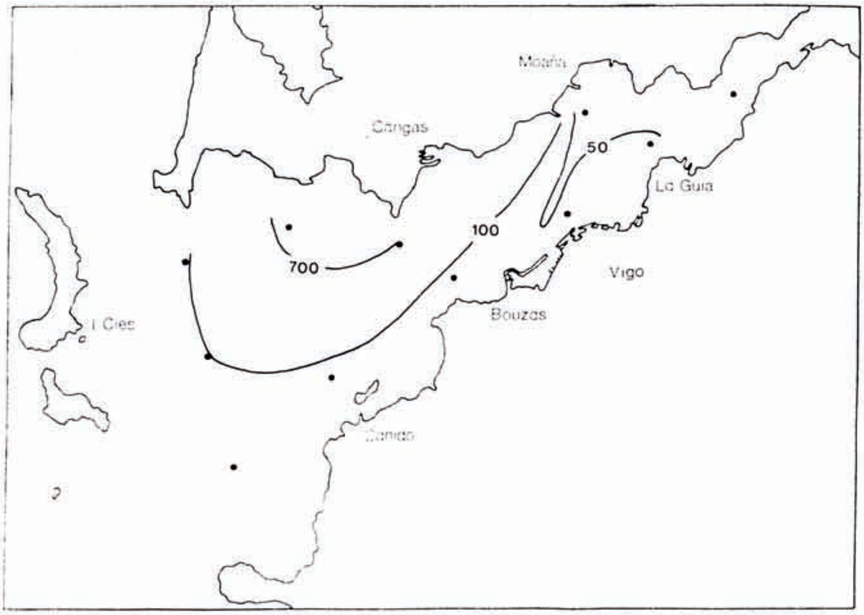


Fig. 9. – Abundance of sprat eggs and their distribution in the Ría of Vigo in November 1979 (eggs/10m^2 of sea water).

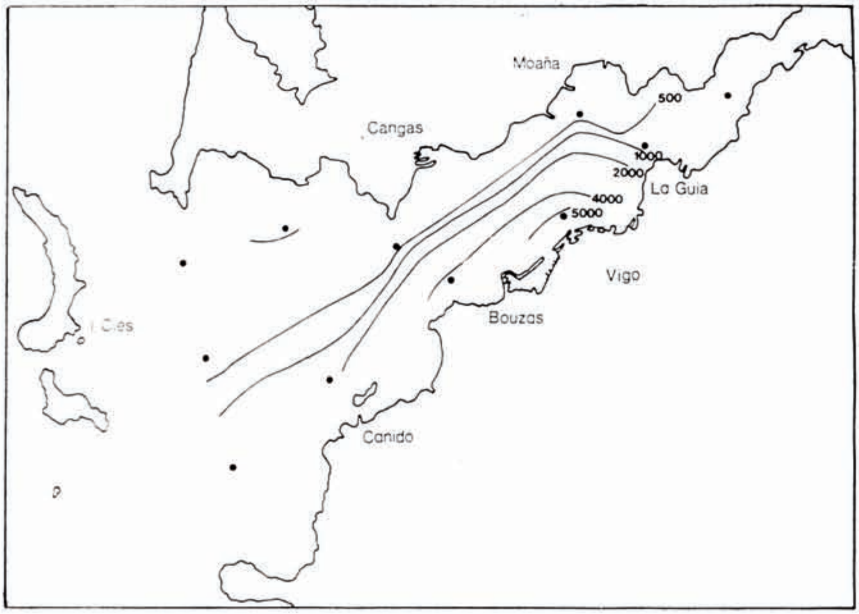


Fig. 10. – Abundance of sprat eggs and their distribution in the Ría of Vigo in January 1980 (eggs/10m^2 of sea water).

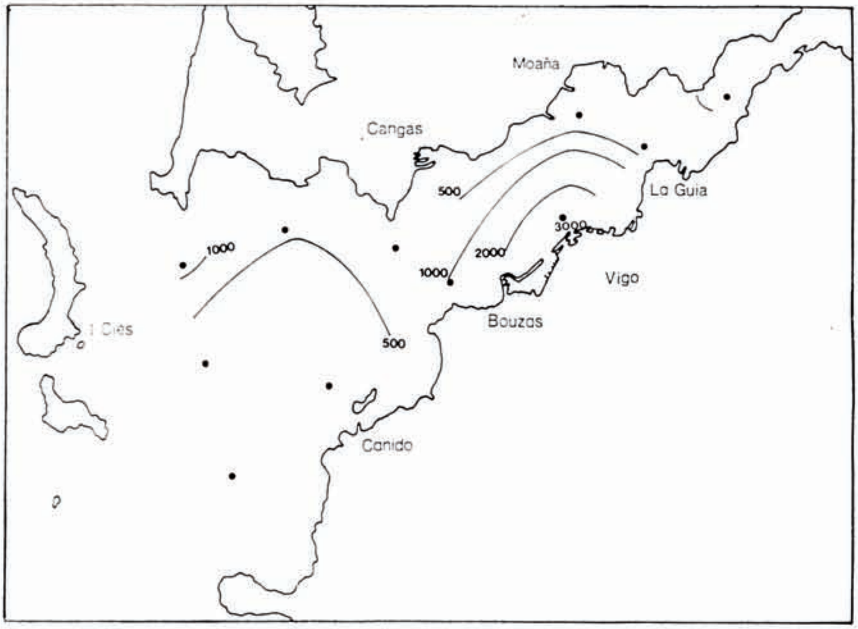


Fig. 11. – Abundance of sprat eggs and their distribution in the Ría of Vigo in February 1980 (eggs/10m^2 of sea water).

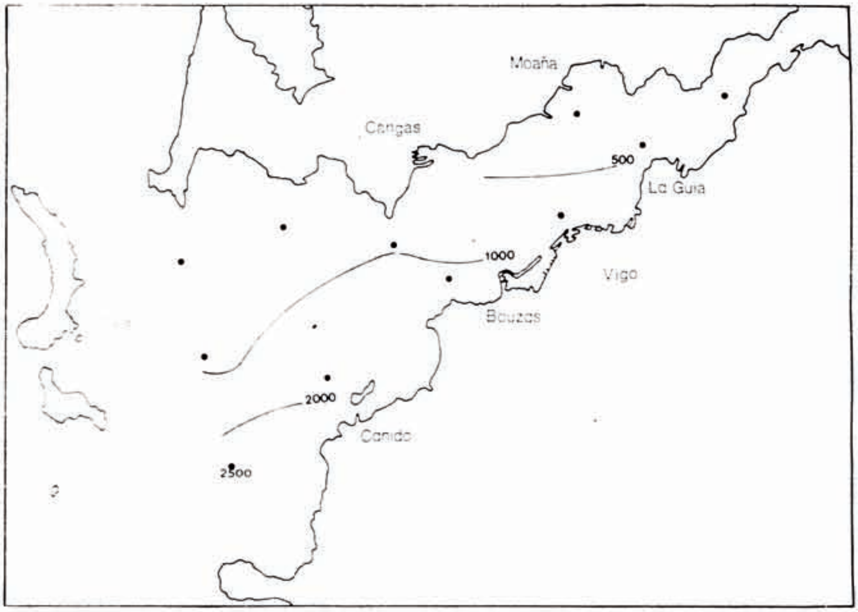


Fig. 12. – Abundance of sprat eggs and their distribution in the Ría of Vigo in March 1980 (eggs/10m^2 of sea water).

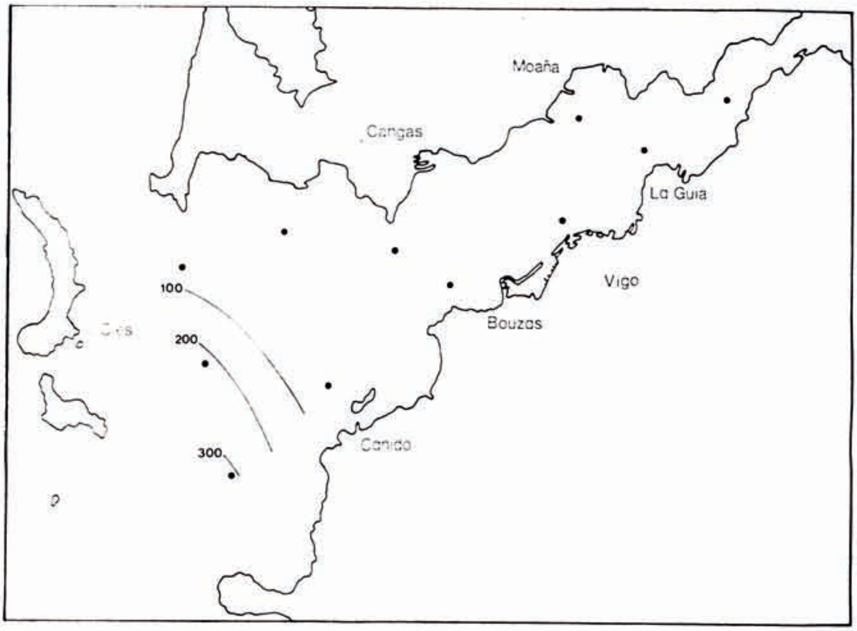


Fig. 13. – Abundance of sprat eggs and their distribution in the Ría of Vigo in April 1980 (eggs/10m^2 of sea water).

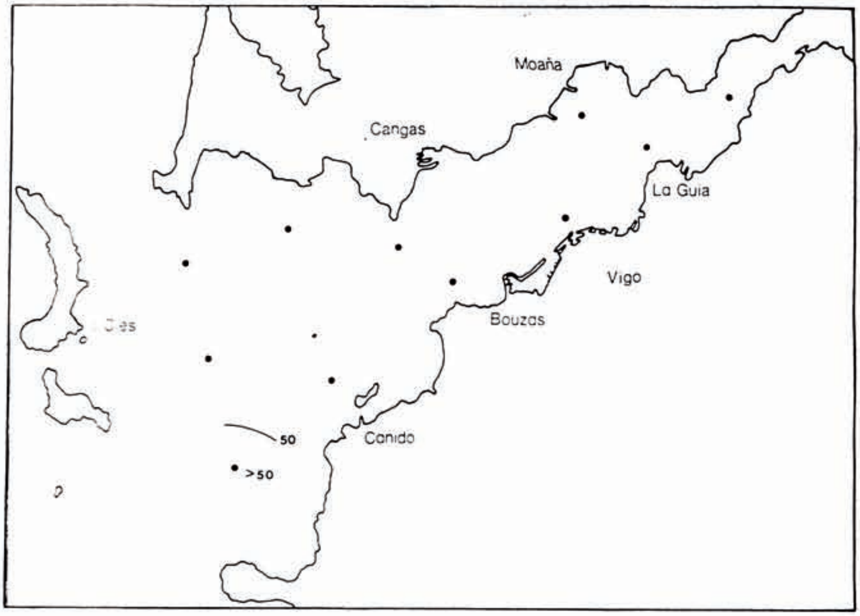


Fig. 14. – Abundance of sprat eggs and their distribution in the Ría of Vigo in May 1980 (eggs/10m^2 of sea water).

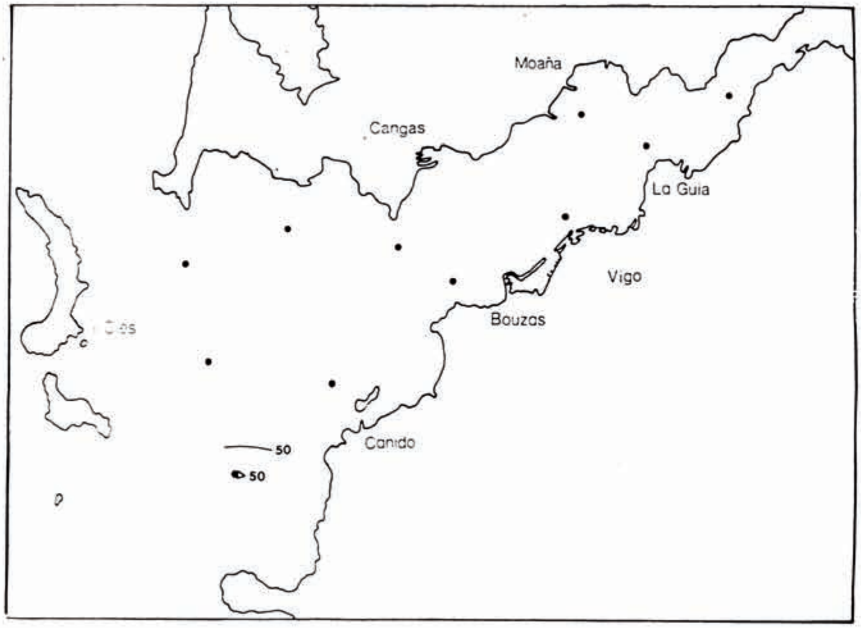


Fig. 15. – Abundance of sprat eggs and their distribution in the Ría of Vigo in June 1980 (eggs/10m^2 of sea water).

With regard to salinity, this does not seem to be a limiting factor because the range recorded in the literature is from 5°/oo in the Baltic Sea to 34-35°/oo in Galician waters ; Fage (1920) stated that mature individuals are attracted to spawn in waters with salinities below 35°/oo, which could explain their migration into the Rias for spawning.

Engraulis encrasicolus (Linnaeus, 1758)

The spawning season and conditions for the anchovy have been observed by numerous authors in different areas and it is generally accepted that spawning takes place at the end of spring in shallow waters near the coast, with relatively high temperatures.

Figures 16 to 18 show the monthly abundance of eggs and their distribution in the Ria of Vigo. The average monthly densities of eggs in the entire survey area is shown in figure 4.

As far as spacial distribution is concerned, the greatest abundance was in the inner part of the Ria, with densities of 270 eggs/10 m^2, while in the central area, eggs were scarce and they disappear in the outer part. This strongly suggests that the anchovies enter the Ria to spawn, as Lopez Veiga (1977) and Lopez-Jamar (1977) noted. Moreover, Ré (1982), who studied the spawning of the anchovy along the Portugueze coast, also found that it takes place in the inner part of the estuaries.

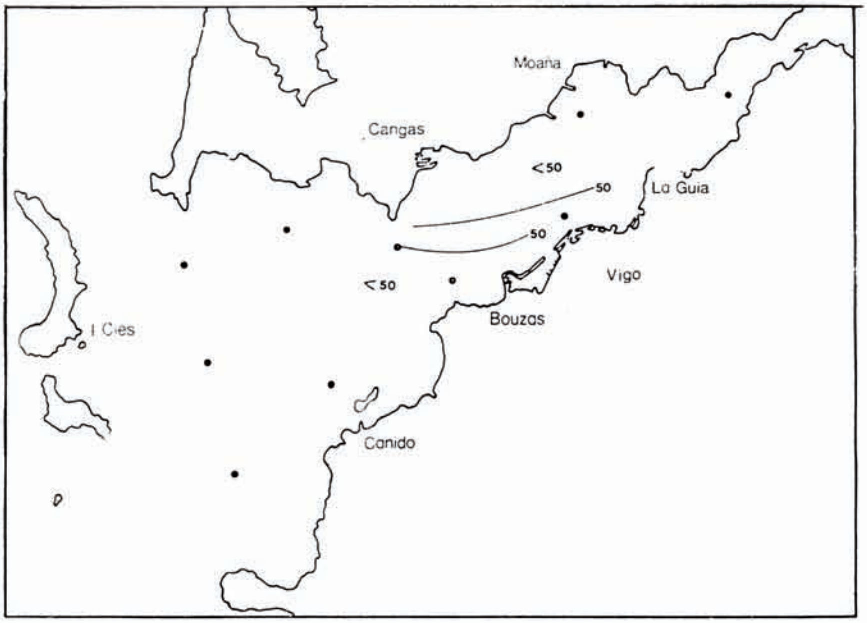


Fig. 16. – Abundance of anchovy eggs and their distribution in the Ría of Vigo in September 1979 (eggs/10m^2 sea water).

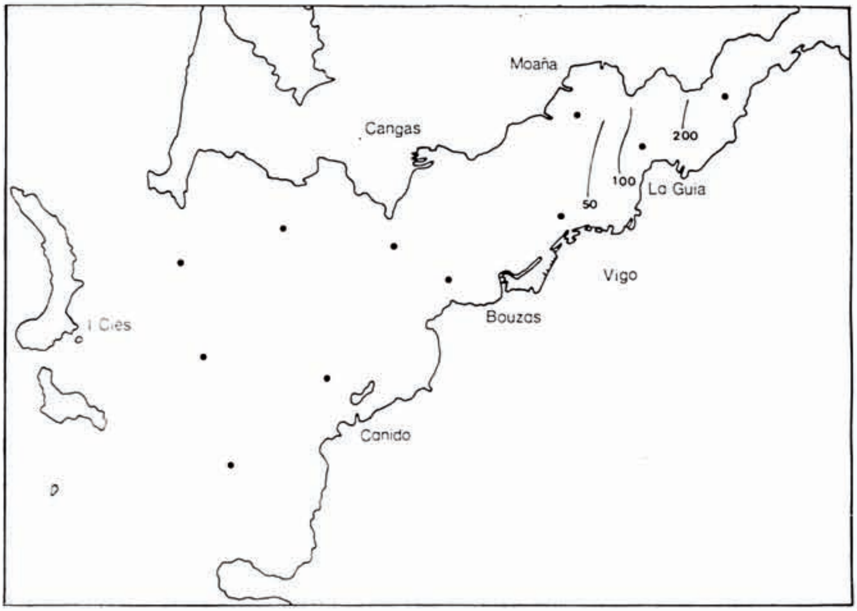


Fig. 17. – Abundance of anchovy eggs and their distribution in the Ría of Vigo in July 1980 (eggs/10 m^2 of sea water).

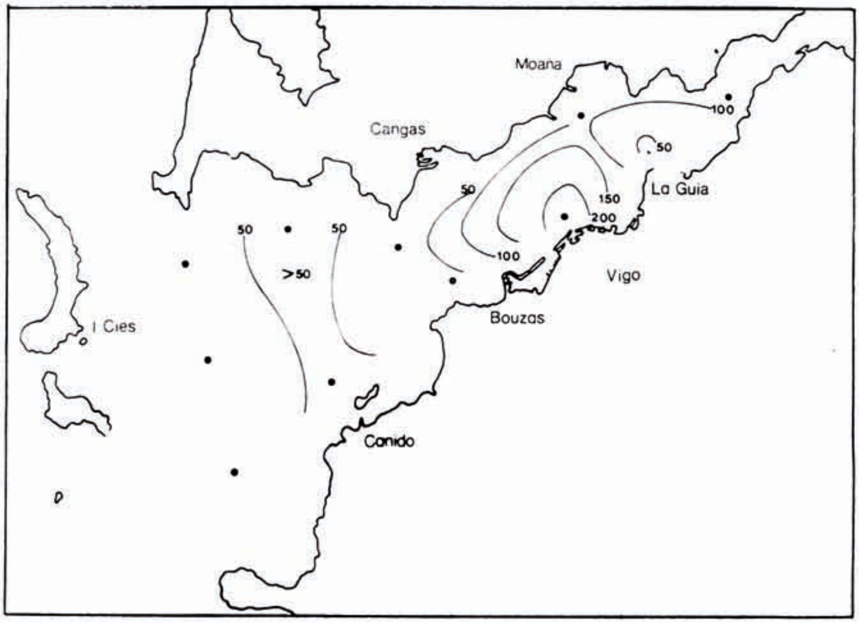


Fig. 18. – Abundance of anchovy eggs and their distribution in the Ría of Vigo in August 1980 (eggs/10m^2 sea water).

The highest abundance in the survey area occured during July and August, although eggs were found from May to September. Thus, there is a summer spawning season. This contradicts the published data for the Cantábrico region (Furnestin 1945, Navarro & Navaz 1946, Andreu 1950, Arbault & Boutin 1968, Arbault & Lacroix 1971, Cendrero & Cort 1975, Cort, Cendrero & Iribar, 1976), which suggest a maximum in spawning at the end of May and during the first fortnight of June. Thus, our data imply a delay of two months. However, data from the Mediterranean (Arné 1931; Aboussouan 1964; Arbault & Tournier, 1971) is more consistent with that of the present work. Off the Galician coast, Lopez Veiga (1977) found anchovy eggs in April and May in the Ría of Vigo. Although he did not present data for other months, Lopez-Jamar (1977), in his study of the ichthyoplankton of the Ria of Arosa, presented data similar to those we have found and Ré (1982) found eggs from February to June, with a peak in April, along the Portuguese coast.

If we relate our spawning date (i.e. abundance of eggs) with average temperatures, we notice that the spawning takes place in a range of temperatures between 14,52° C and 18.29° C, which are the highest water temperatures reached in the Ría. It is also noticeable that in the months of greatest spawning intensity the temperature is higher in the inner part of the Ría than in the outer part. Thus, in July, the average temperature at stations 1, 2, 3, 4 and 5, where there were no anchovy eggs, was 13.35° C, whereas the average at stations in the inner part, with great numbers of eggs, was 14.83° C; in August, when there was an increase in average temperatures throughout the Ría, there were anchovy eggs at stations 4 and 5 where temperatures were 16.94° C and 16.61° C respectively.

It might seem that temperature is the main factor inducing spawning in the inner part of the Ría, since it is there that optimum temperatures for anchovy spawning are reached. According to Arbault & Boutin (1968) optimum temperature are between 15.8° C and 24° C and according to Arbault & Lacroix (1971), between 14° C and 19° C, both measured in the Bay of Biscay.

Moreover, oceanographic studies off Galician coasts (Fraga, 1982) indicate an upwelling consistent with the spawning habits of the anchovy. This involves a cooling of the shallow coastal waters, which would explain the need for the mature individuals to migrate into the warmer waters of the Rías. Water temperatures along our coasts could also explain the retarding of spawning season in comparison with the Portuguese spawning. Thus, Ré (1981) finds the greatest abundances of eggs in April within a temperature range of 13.8 to 15.8° C, while in our survey area, these temperatures are not reached until May-June, April temperatures being only 12.7° C.

On the other hand Demir (1965) states that the optimal temperatures for the anchovy are from 15° C to 25° C and the salinity can vary between 9°/oo and 35°/oo, this wide range must mean that salinity is not a limiting factor, because salinities in the Ría during the year show this same range.

CONCLUSIONS

Spawning areas

The Ría of Vigo cannot be considered part of the main spawning area for the pilchard (*Sardina pilchardus*) off the Galician coasts. Low egg densities in the outer part of the Ría indicate that this is a peripherical area and/or that eggs found there were brought in by water from outside the Ría. The data of Lopez-Jamar (1977) for the Ría of Arosa can also be interpreted in this way.

Nevertheless, our Ría can be defined as a principal spawning area for the sprat (*Sprattus sprattus*) with a nucleus in the central part of the Ría.

As far as the anchovy (*Engraulis encrasicolus*) is concerned, it has a principal spawning area in the inner part of the Ría of Vigo; the relatively low abundance of eggs must be related to the scarcity of anchovy in the Rías Bajas and along the Galician coasts.

Spawning season

The survey area is not a principal spawning area for the pilchard, but one can conclude that it has a long and mainly winter/spring spawning season (from November to July), but with two periods of greater spawning activity in November and May.

The sprat also has a long spawning season, mostly in winter, spring, from October to June, with a maximum activity in January, February and March.

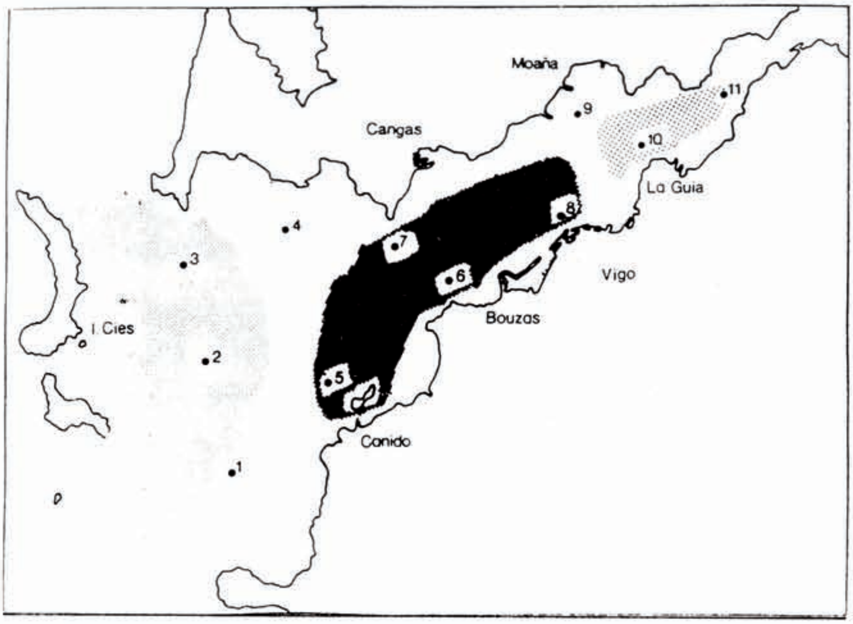


Fig. 19. – Spatial distribution in the Ría of the spawning of the three species (anchovy, sprat and pilchard).

The anchovy must be considered in this area as a summer spawner (from May to September), with maximum spawning activity in July and August.

Ambiental factors : temperature and salinity

Our data suggest that salinity does not play a determinant role in the spawning of clupeoids in the Ría of Vigo.

Temperature seems to play an important role in determining spawning areas and seasons for the three species considered here. Thus, the pilchard and sprat spawn within a temperature range of 13 to 15° C, while the anchovy requires 14.5 to 18° C, found only during a short period in the inner part of the Ría.

These conclusions are shown in Figure 19.

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Table 1. – Monthly captures of eggs of each of the considered species expressed as eggs/10 m2 of sea surface and average temperature and salinity of the colomn of water for each station (S = *Sardina pilchardus*; Sp = *Sprattus sprattus*; E = *Engraulis encrasicholus*).

Month	Species \ Stations	1	2	3	4	5	6	7	8	9	10	11	X
IX-79	S	0	0	0	8	0	0	0	0	0	0	0	1
	Sp	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	14	0	0	0	0	51	76	8	16	17	17
	T (°C)	14,48	14,49	15,93	15,98	15,70	15,63	15,78	16,10	16,65	16,30	16,45	
	S°/oo	35,133	34,828	35,070	35,146	35,031	34,861	35,009	35,152	35,150	35,214	35,264	
X-79	S	0	0	0	0	0	-	-	-	-	-	-	0
	Sp	20	28	17	17	17	-	-	-	-	-	-	20
	E	0	0	0	0	0	-	-	-	-	-	-	0
	T (°C)	15,87	15,68	15,75	15,55	15,60	-	-	-	-	-	-	
	S°/oo	34,938	34,674	34,368	34,384	34,674	-	-	-	-	-	-	
XI-79	S	374	169	68	51	144	213	76	59	0	12	0	106
	Sp	0	169	85	823	8	0	755	68	11	44	17	180
	E	0	0	0	0	0	0	0	0	0	0	0	0
	T (°C)	13,50	13,74	13,80	13,95	13,43	13,55	13,95	13,90	13,90	13,88	13,85	
	S°/oo	35,203	35,353	35,311	35,235	34,994	34,946	35,176	35,049	35,007	34,699	34,507	
I-80	S	0	28	0	0	0	0	0	0	0	0	0	3
	Sp	1790	169	441	526	1663	4508	218	5218	110	734	882	1478
	E	0	0	0	0	0	0	0	0	0	0	0	0
	T (°C)	12,90	12,90	12,68	12,73	12,85	12,48	12,88	13,03	12,47	12,88	12,83	
	S°/oo	35,406	35,261	35,101	35,076	35,169	35,051	35,032	35,247	34,673	35,080	34,757	
II-80	S	0	0	0	0	0	0	0	0	0	0	0	0
	Sp	0	0	1137	535	42	978	764	2944	28	212	611	659
	E	0	0	0	0	0	0	0	0	0	0	0	0
	T (°C)	12,95	12,82	12,83	12,78	12,80	12,83	12,78	12,80	12,70			
	S°/oo	34,176	*32,480	*31,345	*31,653	*32,331	*31,361	*29,969	*30,954	*28,986			
III-80	S	571	254	399	153	335	27	13	17	1	12	0	163
	Sp	2498	677	590	552	1773	1099	933	768	58	361	233	867
	E	0	0	0	0	0	0	0	0	0	0	0	0
	T (°C)	13,10	13,14	13,15	13,18	13,20	13,23	13,23	13,18	13,37	13,25	13,03	
	S°/oo	35,305	35,093	34,989	35,011	35,260	35,202	35,023	35,348	34,614	34,610	34,338	

* Salinity of sea surface.

IV-80	S	315	63	4	0	89	0	0	0	0	0	0	43
	Sp	315	233	64	34	25	96	30	30	0	6	0	76
	E	0	0	0	0	0	0	0	0	0	6	0	0
	T (ºC)	13,15	13,16	13,23	13,25	13,10	13,18	13,25	13,15	13,30	13,23	13,23	
	Sº/oo	35,430	35,228	34,936	34,936	35,404	35,275	34,895	35,377	34,339	34,583	34,620	
V-80	S	49	35	4	8	17	4	8	4	0	0	0	12
	Sp	79	7	13	4	0	4	0	0	0	0	0	10
	E	0	0	0	0	0	22	4	0	0	3	0	3
	T (ºC)	14,22	14,42	14,60	14,60	14,35	14,65	14,55	14,80	15,03	14,33	14,85	
	Sº/oo	34,753	34,465	34,145	34,242	34,216	34,231	34,214	34,377	33,854	33,884	33,499	
VI-80	S	10	0	127	4	4	4	0	0	0	0	0	14
	Sp	59	21	13	21	29	26	17	0	0	0	0	17
	E	30	0	0	0	30	0	4	0	0	6	0	6
	T (ºC)	13,47	13,70	13,73	13,88	14,20	14,48	14,38	14,38	14,73	14,70	14,80	
	Sº/oo	35,586	35,566	35,568	35,560	35,519	*35,325	*35,475	*35,328	*35,329	*35,186	*35,162	
VII-80	S	128	42	25	0	4	0	0	0	0	0	0	18
	Sp	20	6	34	8	8	0	0	0	0	0	0	7
	E	0	0	0	8	0	29	51	8	6	139	272	47
	T (ºC)	12,78	12,86	13,48	14,25	13,60	14,85	14,65	14,75	15,13	14,85	14,95	
	Sº/oo	35,580	35,581	35,571	35,519	35,461	35,326	35,338	35,363	35,187	35,132	34,828	
VIII-80	S	0	0	0	0	0	0	0	0	0	0	0	0
	Sp	0	0	0	0	0	0	0	0	0	0	0	0
	E	10	0	8	85	64	15	8	246	109	40	119	64
	T (ºC)	15,47	15,74	16,93	16,98	16,65	16,93	16,98	16,90	18,33	17,33	17,05	
	Sº/oo	35,333	35,298	35,208	35,124	35,167	35,145	35,138	35,116	34,991	35,071	35,049	
IX-80	S	0	0	4	0	0	0	0	0	0	0	0	0
	Sp	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	7	0	0	4	0	4	8	1	28	0	5
	T (ºC)	13,80	14,40	14,38	14,43	14,43	14,70	14,43	14,75	15,40	15,35	14,85	
	Sº/oo	35,467	35,448	35,441	35,419	35,368	35,362	35,409	35,356	35,352	35,343	35,365	
X-80	S	0	0	8	0	0	0	0	0	0	0	–	1
	Sp	10	0	0	0	0	0	0	0	0	0	0	1
	E	0	0	0	0	0	0	0	0	0	0	–	0
	T (ºC)	14,65	15,08	15,70	15,43	15,28	15,25	15,60	16,10	16,00	15,28		
	Sº/oo	35,357	35,297	35,223	35,212	35,236	35,213	35,218	35,256	35,138	35,201		